Technical Permit Revision to NSR Permit 1081-M1-R5
Beryllium Furnace Replacement

This application is for a revision to existing NSR Permit 1081-M1-R5. Permit 1081 was issued for beryllium machining and furnace operations at the Plutonium Facility within Technical Area (TA)-55. The purpose of the application is to allow the replacement of the existing furnace which is currently permitted under Permit 1081 with an equivalent unit which is of a different design. There are no revisions requested for beryllium machining operations within this application.

Attachment A contains the signed application certification required of all permit applications, including technical permit revisions.

Permit 1081 Summary

Permit 1081 was first issued to Los Alamos National Laboratory (LANL or the Laboratory) in 1992 for machining operations on beryllium parts subject to regulation under the beryllium National Emission Standard for Hazardous Air Pollutants (NESHAP) at 40 CFR Part 61, Subpart C. These permitted activities are located at Technical Area (TA)-55 within the Laboratory's Plutonium Facility. Over the years, Permit 1081 has been modified once and revised five times.

The most extensive revision to the permit was Revision 3 issued in February 2000. This revision established new emission limits for beryllium machining operations and a new furnace to be used in melting beryllium parts. Revision 3 also established new process throughput limits for beryllium parts, as well as emission testing, monitoring, and recordkeeping requirements. Revision 3 was processed as a technical permit revision by NMED as provided for by 20.2.72.219.B. Note that the permit references the existing furnace as a *foundry* operation. This term is used because the beryllium NESHAP defines *foundry* broadly as "a facility engaged in the melting or casting of beryllium metal or alloy."

The furnace which is currently permitted under Revision 3 was designed by LANL and is described in the permit as the "vacuum induction melt furnace." This vacuum furnace was installed but to date has not been used.

Need for Furnace Replacement

LANL conducts research, development, and demonstration activities at TA-55 in support of national security. Certain of these activities can generate a need for the sanitization of beryllium parts, i.e. the untreated beryllium part contains classified information. A small laboratory-scale furnace is needed for this purpose. The furnace is intended to sanitize beryllium parts through melting into beryllium ingots. A safety issue was identified with the existing furnace which prevented operation from ever occurring and necessitates its replacement.

Description of New Furnace

Information on the new furnace is included in Attachment B. It is a laboratory furnace manufactured by CM Furnaces and designated Model 1712 with molydisilicide heating elements. As described, the outer dimensions of this unit in inches are 18.5 x 25.5 x 19. Heat is supplied from electrical power. As shown in the vendor specification sheet, the maximum temperature of the furnace is 1600 degrees C because an inert gas will be used during operation.

Technical Permit Revision Criteria

20.2.72 NMAC provides for three types of permit modifications: administrative, technical, and significant permit revisions. There are five separate criteria in the rule, any one of which if met, defines a technical permit revision. This application is submitted as a technical revision to Permit 1081 because it qualifies under two of these criteria. These two criteria are described below.

20.2.72.219.B.1.b states technical permit revision procedures may be used for "Permit revisions that incorporate a change in the permit solely involving additional equipment with a potential emission rate of no more than one (1) pound per hour for any pollutant for which a National or New Mexico Ambient Air Quality Standard has been set or one (1) pound per hour for any VOC". There is no National or New Mexico Ambient Air Quality Standard for beryllium. However, beryllium and all other potential emissions are emitted in the form of particulate matter which does have both federal and New Mexico ambient standards established. As shown in Attachment C, the potential emission rate for beryllium and other metals as particulate matter are orders of magnitude below one pound per hour. Under this criteria, the new furnace qualifies for the technical revision process.

20.2.72.219.B.1.d states technical permit revision procedures may also be used for "Modifications that replace an emissions unit for which the allowable emissions limits have been established in the permit…". This describes the intent of this application. There are seven criteria, numbered (i) through (vii), which must be met under this provision for technical permit revisions. Each criteria is met by this modification as described below.

(i) Is equivalent to the replaced emissions unit, and serves the same function within the facility and process;

The new CM furnace will replace the existing vacuum furnace. It will serve precisely the same function, in the same facility, and in the same process as the vacuum furnace. The replacement is needed to address a safety issue. The furnace purpose and use has not changed.

(ii) Has the same or lower capacity and potential emission rates;

For the new CM furnace, the capacity and potential emission rates are each defined by the existing enforceable limitations in existing Permit 1081. The capacity of the furnace is as specified in Permit 1081: beryllium processing shall not exceed 20 kg (44.0 lb) per 24 hour period or 500 kg (1100 lb) per year. The potential emission rates are the allowable emission limits for the foundry in Permit 1081: 3.49×10^{-5} grams per 24 hours and 8.73×10^{-4} grams per year.

Note the definition of *potential emission rate* at 20.2.72.7.Y is "means the emission rate of a source at its maximum capacity to emit a regulated air contaminant under its physical and operational design, provided any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored or processed, shall be treated as part of its physical and operational design only if the limitation or the effect it would have on emissions is enforceable by the department pursuant to the Air Quality Control Act or the federal Act".

(iii) Has the same or higher control efficiency, and stack parameters which are at least as effective in the dispersion of air pollutants;

There will be no change in either the control efficiency or stack parameters associated with the furnace replacement. Beryllium emissions from the new CM furnace will be controlled by a 4-stage HEPA filter system with each having an installed control efficiency of 99.95% as required by Permit 1081. The new furnace will be vented to the same stack at TA-55 as the vacuum furnace.

(iv) Would not result in an increase of the potential emission rate of any other equipment at the facility;

The use, model type, or size of the furnace has no influence on the potential emission rate of other equipment. The furnace is used sporadically to sanitize beryllium parts generated from research and development activities.

(v) Shall be subject to the same or lower allowable emissions limits under the permit, and to all other permit conditions which have applied to the replaced emissions unit;

This application does not request any change to the existing allowable emission limits or any other conditions in Permit 1081 which apply to the existing furnace.

(vi) Would not, when operated under applicable permit conditions, cause or contribute to a violation of any National or New Mexico Ambient Air Quality Standard;

There is neither a National nor New Mexico Ambient Air Quality Standard for beryllium. When viewed as particulate matter, the maximum lb/hr emission rates shown in Attachment C are negligible and could have no impact on ambient standards for particulate matter.

(vii) Would not, as determined by the Department, require additional permit conditions in order to ensure the enforceability of the permit, such as additional record keeping or reporting to show compliance;

There are no additional permit conditions required to ensure the enforceability of the permit. Existing monitoring, recordkeeping, and reporting permit conditions in Permit 1081 which will apply to the new CM furnace include: monitoring and daily recordkeeping of the pressure drop across HEPA filters, annual HEPA filter challenge tests, a stack emission test for beryllium after startup of the furnace, and records of the number and weight of classified parts processed.

The requirements cited above were evaluated by the Air Quality Bureau during the review of the Laboratory's Title V operating permit application and determined to be sufficient to ensure compliance. These conditions were incorporated within Title V Permit P100 issued in April 2004 to LANL. In addition, under Permit P100 new compliance requirements beyond those in Permit 1081 were established. These include an annual compliance certification report, a semiannual monitoring report, and a semiannual emissions report. All of these reports under Title V include beryllium activities at TA-55, and are intended to enhance compliance.

Emission Estimates

Attachment C contains emission estimates for the new furnace. Additional support information for the estimates is included in Attachment D. These extremely low estimated emission rates are themselves conservative, over-estimates of potential emissions. An evaluation of the predicted emission rates should consider the following points:

- The furnace will be enclosed in a glove box which is exhausted through the HEPA filtration system to an exhaust stack. There is no exhaust fan on the furnace itself which forces air through the furnace vent into the glove box. For purposes of these estimates, it is assumed the low glove box exhaust rate will draw air from the furnace into the glove box.

- It will take several hours to bring the furnace up to the melting point of the metal. Once there, it is anticipated the actual melt time will be 30 minutes or less. The potential generation of a metal vapor within the furnace will only take place during this melt time period. These emission estimates assume generation of a vapor through the full hour.

- Furnace temperature will be carefully monitored and will be just at or slightly above the melting point of the metal. These calculations assume much higher operating temperatures, in some cases the maximum temperature achievable by the furnace, which results in higher emission estimates.

- It is assumed that the concentration of metal vapor generated within the furnace is equivalent to the concentration actually exhausted from the glove box. In other words, it is assumed there is no dilution of the vapor concentration from the mixing of any gas flow from the furnace within the glove box volume. This assumption also results in higher predicted emissions.

- Permit 1081 requires operation of a 4-stage HEPA filter control system. The estimates of controlled emission rates only take credit for one HEPA filter stage. This results in an over-estimation of controlled emissions.

As shown in Attachment C, the maximum theoretical beryllium emission rate is below the existing emission limit in Permit 1081. The same is true for the estimated aluminum emission rate. Emission estimates are also provided for other metals identified which may also be in parts which need to be sanitized within the furnace. The estimated potential emission rate for each metal is well below the permit applicability thresholds for toxic air pollutants (TAPs) in 20.2.72 NMAC. We note that 20.2.72 NMAC does not require emission estimates in a permit application or revision for TAPs when the emission rate is below the lb/hr permit applicability thresholds. This information therefore is submitted voluntarily, and should not result in any new permit conditions.

The metal parts which need to be sanitized may be contaminated with radionuclides. The exhaust stacks at the Plutonium Facility are monitored under the requirements of the applicable federal Clean Air Act regulation at 40 CFR Part 61, Subpart H - National Emission Standard for Emissions of Radionuclides other than Radon from Department of Energy Facilities. This program is regulated by the Environmental Protection Agency. Authority for this program has not been delegated to the New Mexico Environment Department.

<u>Public Notice</u>

Attachment E contains documentation of the required public notice provided to the local newspaper and nearby governments.

Attachment A

Certification

Certification

Company Name: University of California for the U.S. Department of Energy

We, Dianne Wilburn and Steven McKee ______________________, hereby certify that the information and data submitted in this application are true and as accurate as possible, to the best of our knowledge and professional expertise and experience.

Signed this ____ day of ________________, 2006 ______, upon my oath or affirmation, before a notary of the State of _____New Mexico.

_______________________________________ ________________

Signature Date

Dianne Wilburn Acting Group Leader – ENV-MAQ

Printed Name Title

_______________________________________ ________________

Signature Date

Steven McKee Group Leader – NMT-15

Printed Name Title

Scribed and sworn before me on this ____ day of __________________, 2006 ______.
My authorization as a notary of the State of New Mexico _____________expires on the _________________ day of __________________, 2006 ___________.

________________________ ________________

Notary's Signature Date

____

Notary's Printed Name

Attachment B

Furnace Vendor Information

1700 SERIES

RAPID TEMP LAB FURNACES 1700°C (3100°F)

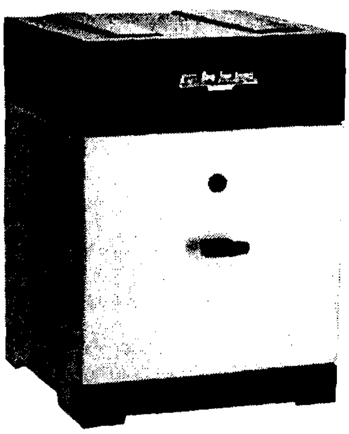
The most reliable and widely used lab furnaces available today, the CM 1700 Series Rapid Temp Lab Furnaces offer rapid heating and cooling rates, uniform temperature control, compactness, and sturdy construction for long term use. Configurations are available for virtually any requirement with four basic configurations including front and bottom loading box furnaces, horizontal and vertical tube furnaces. Gas sealed systems, thermal cycling systems, as well as custom designs and specialized control systems are offered.

The 1700 Series furnaces incorporate a graded insulation package using high purity alumina fiber. Due to the low thermal conductivity and light weight of this insulation extraordinary fast thermal cycling is possible. These furnaces will not hot spot at high temperatures and are resistant to degradation. The double wall shell construction allows the fan cooling feature to maintain reduced skin temperatures while keeping the element terminals cool.

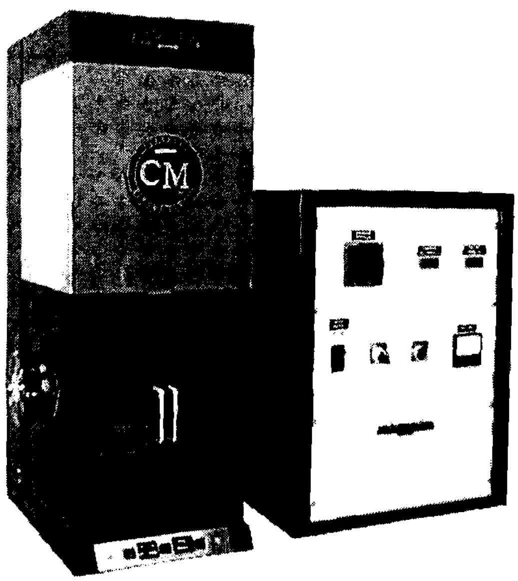
Kanthal Super 1800 molydisilicide heating elements are used, offering fast heat up rates and long life in oxidizing atmospheres. These elements are not subject to normal watt loading limitations and are not affected by thermal shock, therefore heat-up rates are only limited by the capability of the power supply. The electrical resistivity of these elements remains constant over long periods without aging so that individual elements can be replaced without having to match resistance values.

The Rapid Temp Control and Power Supply console includes all components required for immediate installation and operation. Proper control of molydisilicide requires a phase angle-fire SCR, step-down transformer and independent overtemperature instrumentation. Standard control instrumentation includes a multiple segment programmable microprocessor such as Honeywell or Eurotherm used in conjunction with a Type "B" thermocouple.

In addition to offering standard atmosphere options with the tube furnaces, CM also offers a gas-sealed option on our box furnaces for inert atmosphere operation. (The use of inert gas with molydisilicide elements reduces the maximum operating temperature by 100°C.)



Model 1712 Front Loader



Model 1710 Bottom Loader

USED FOR THESE AND OTHER APPLICATIONS:

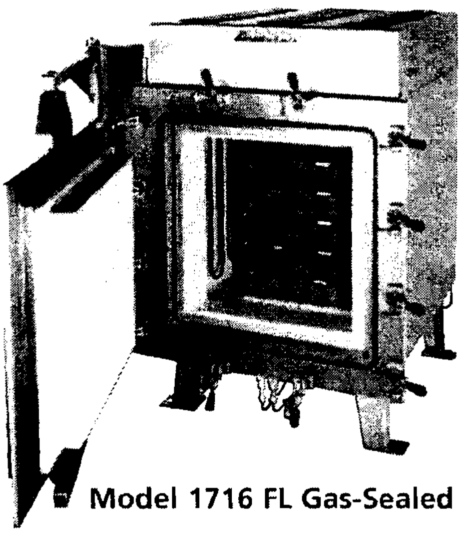
- Ceramics
- Glass
- Powders
- Laboratory Research
- Materials Testing
- Thermal Cycling
- Sintering
- Annealing
- Firing

CM FURNACES INC.

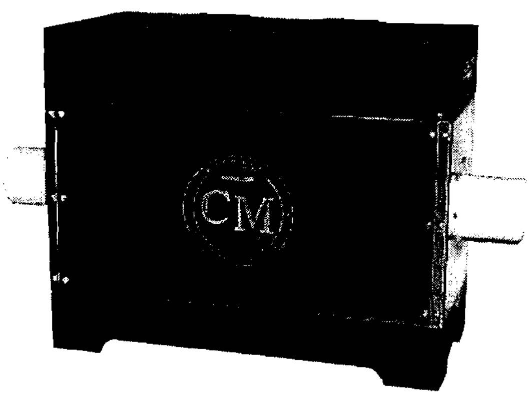
industrial and laboratory furnaces

www.cmfurnaces.com

SPECIFICATIONS



Model 1716 FL Gas-Sealed



Model 1730-12 Horizontal Tube

FULL SYSTEM INCLUDES:

- Double Shell Construction
- High Purity Alumina Fiber Insulation
- Kanthal Super 1700 Molydisilicide Heating Elements
- Cubed Chamber for Best Uniformity
- Fan Cooling of Element Terminals
- Type "B" Thermocouples
- Independent Overtemperature Thermocouple and Instrument
- Programmable Ramp and Soak Control
- Phase Angle-Fire SCR Power Controller
- Step Down Transformer
- Ammeter and Voltmeter
- Separate Controls/Power Supply Console
- 10' Interconnecting Wire and T/C Extension Leads

CONFIGURATIONS:

- Front Loading Box Furnace (FL)
- Bottom Loading Box Furnace (BL)
- Gas-Sealed Box Furnace (FL)
- Thermal Cycling Box Furnace
- Horizontal Tube Furnace (HTF)
- Vertical Tube Furnace (VTF)
- Custom Materials Testing Configurations

MODEL	1704 FL	1706 FL/BL	1708 FL/BL	1710 FL/BL	1712 FL/BL	1716 FL/BL	1730-12 HTF	1730-20 HTF	1730-10 VTF
Chamber WxHxD IDxL	4x4x4	6x6x6	8x8x8	10x10x10	13x11.5x12	16x16x16	3x12	3x20	3x10
Door Opening WxH (FL)	3x3.75	4.5x4.5	5.5x6.5	8x8.5	10.5x10	13x13	3 ID	3 ID	3 ID
Outside Dim. WxHxD (FL)	11x18.5x12.5	11x18.5x12.5	13x20.5x14.5	15x22.5x16.5	18.5x25.5x19	22.5x31x24.5	11x18.5x22	11x18.5x29.5	14 OD x 22
Heatup Rate Minutes	50	25	25	25	50	90	N/A	N/A	N/A
Furnace Weight (LBS)	45	50	70	90	120	260	50	75	55
Number of Elements	4	6	8	10	6	8	10	16	8
Power Supply Dimensions WxHxD	22.5x16x18	22.5x29.5x18	22.5x29.5x18	22.5x29.5x18	22.5x40x18	22.5x61x18	22.5x29.5x18	22.5x29.5x18	22.5x29.5x18
Power Supply Weight (LBS)	75	148	175	175	230	275	148	175	175
Power Requirement (Max) KVA	2.0	4.5	10	10	15	18	7.5	10	9
Power Requirement (Nominal) KVA	1.4	1.6	2.7	4.3	6.4	8.8	2.5	4.5	3.7
Standard Voltage Requirement	110 1-Phase	208/240 1-Phase	208/240 1-Phase	208/240 1-Phase	208/240 1-Phase	208/240 3-Phase	208/240 1-Phase	208/240 1-Phase	208/240 1-Phase
Service Entrance Current Requirement at 208 Volts	20	30	60	60	90	70	45	60	60

103 Dewey Street • Bloomfield, NJ 07003 • Tel: 973.338.6500 • Fax: 973.338.1625
www.cmfurnaces.com • email: info@cmfurnaces.com

Attachment C

Emission Calculations

Summary of Emission Estimates

	Emission Rate lb/hr Uncontrolled	Controlled[1]	TAP Threshold[2]
Beryllium	5.25E-06	2.62E-09	n/a
Aluminum	2.34E-11	1.17E-14	6.67E-01
Uranium	8.97E-09	4.49E-12	1.33E-02
Vanadium	1.39E-07	6.97E-11	3.33E-03
Nickel	9.07E-06	4.54E-09	6.67E-02
Copper	3.14E-04	1.57E-07	1.33E-02
Iron[3]	1.79E-05	8.95E-09	3.33E-01
Chromium[3]	3.11E-04	1.56E-07	3.33E-02
Molybdenum[3]	8.44E-12	4.22E-15	3.33E-01
Manganese[3]	1.73E-02	8.64E-06	6.67E-02

Notes

[1]Controlled values represent potential emission rates for TAP applicability because the 4-stage HEPA filtration control system is an enforceable conditon in Permit 1081. Credit is taken only for 1 of 4 HEPA filtration stages.

[2]From 20.2.72 NMAC, Section 502 Toxic Air Pollutants and Emissions.

[3]Component of Type 304 or 316 stainless steel.

Summary of Emission Estimates

	Emission Rates grams/24-hr Uncontrolled	Controlled	Permit Emission Limit[1]
Beryllium	5.71E-02	2.86E-05	3.49E-05
Aluminum	2.55E-07	1.27E-10	3.49E-05

Notes

[1]From Permit 1081. Also represents the potential emission rate for the proposed furnace.

Beryllium Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1350	C
	2921.67	R
	1623.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Beryllium Melting Point[1]	1287	C
	1560.15	K

Beryllium Vapor Pressure at 1350 C

Assume: Be solid/liquid and vapor is at equilibrium in furnace

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	5.786
B=	-15731
C=	0
D=	0
T(K)=	1623.15

log P = -3.91E+00

P= 1.24E-04 atm

Beryllium Emission Estimates

Beryllium Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole Be
P=	1.24E-04	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	2921.67	R
n=	6.05E-08	lb-mole Be
	9.01	lb Be/lb-mole Be
	5.45E-07	lb Be
Or mass concentration =	5.25E-07	lb Be/ft^3

Uncontrolled Beryllium Particulate Mass Emission Rate

Conservative assumptions:
- Continuous melt of Be during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Be concentration within glove box prior to exhaust

	5.25E-07	lb Be/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	5.25E-06	lb Be/hr	
	1.26E-04	lb Be/24-hr	
	2.38E-03	gram Be/hr	
	5.71E-02	gram Be/24-hr	

Controlled Beryllium Particulate Mass Emission Rate

Conservative assumption: 99.95 % installed removal efficiency - credit for (1) of (4) HEPA filtration stages

Emission rate =	2.62E-09	lb Be/hr
	6.30E-08	lb Be/24-hr
	1.19E-06	gram Be/hr
	2.86E-05	gram Be/24-hr

Notes

(1) From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2) Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Aluminum Emission Estimates

Operational Data

Furnace Chamber Volume		12	in length
		11.5	in height
		13	in width
	Volume	1794.00	in^3
		1.04	ft^3
Maximum Operating Temperature		750	C
		1841.67	R
		1023.15	K
Maximum Glove Box Flowrate		10	ft^3/hr
Aluminum Melting Point[1]		660.32	C
		933.47	K

Aluminum Vapor Pressure at 750 C

Assume: Al solid/liquid and vapor is at equilibrium in furnace

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm	
A=	5.911
B=	-16211
C=	0
D=	0
T(K)=	1023.15

log P = -9.93E+00

P= 1.17E-10 atm

Aluminum Emission Estimates

Aluminum Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole Al
P=	1.17E-10	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	1841.67	R
n=	9.00E-14	lb-mole Al
	26.98	lb Al/lb-mole Al
	2.43E-12	lb Al
Or mass concentration =	2.34E-12	lb Al/ft^3

Uncontrolled Aluminum Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Al during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Al concentration within glove box prior to exhaust

	2.34E-12	lb Al/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	2.34E-11	lb Al/hr	
	5.62E-10	lb Al/24-hr	
	1.06E-08	gram Al/hr	
	2.55E-07	gram Al/24-hr	

Controlled Aluminum Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	1.17E-14	lb Al/hr
	2.81E-13	lb Al/24-hr
	5.31E-12	gram Al/hr
	1.27E-10	gram Al/24-hr

Notes

(1)From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2)Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Uranium Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Uranium Melting Point[1]	1135	C
	1408.15	K

Uranium Vapor Pressure at 1600 C

Assume: U solid/liquid and vapor is at equilibrium in furnace

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	20.735
B=	-28776
C=	-4.0962
D=	0
T(K)=	1873.15

log P = -8.03E+00

P= 9.28E-09 atm

Uranium Emission Estimates

Uranium Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole U
P=	9.28E-09	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	3.91E-12	lb-mole U
	238.03	lb U/lb-mole U
	9.31E-10	lb U
Or mass concentration =	8.97E-10	lb U/ft^3

Uncontrolled Uranium Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of U during full hour time period
- Continuous flow from furnace to glove box
- No dilution of U concentration within glove box prior to exhaust

	8.97E-10	lb U/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	8.97E-09	lb U/hr	

Controlled Uranium Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	4.49E-12	lb U/hr

Notes

(1) From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2) Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Vanadium Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Vanadium Melting Point[1]	1910	C
	2183.15	K

Vanadium Vapor Pressure at 1600 C

Assume: V solid/liquid and vapor is at equilibrium in furnace
V combined with Al to lower melting point

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	6.929
B=	-25011
C=	0
D=	0
T(K)=	1873.15

log P = -6.42E+00

P= 3.77E-07 atm

Vanadium Emission Estimates

Vanadium Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole V
P=	3.77E-07	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	1.59E-10	lb-mole V
	50.942	lb V/lb-mole V
	8.10E-09	lb V
Or mass concentration =	7.81E-09	lb V/ft^3

Uncontrolled Vanadium Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of V during full hour time period
- Continuous flow from furnace to glove box
- No dilution of V concentration within glove box prior to exhaust

	7.81E-09	lb V/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate, as V =	7.81E-08	lb V/hr	
	1.53E-09	lb-mole V/hr	
Emission rate, as V_2O_5 =	7.66E-10	lb-mole V_2O_5/hr	
	1.39E-07	lb V_2O_5/hr	

Controlled Vanadium Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate, as V =	3.90E-11	lb V/hr
Emission rate, as V_2O_5 =	6.97E-11	lb V_2O_5/hr

Notes

(1)From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2)Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Nickel Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Nickel Melting Point[1]	1455	C
	1728.15	K

Nickel Vapor Pressure at 1600 C

Assume: Ni solid/liquid and vapor is at equilibrium in furnace

[2]$\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	6.666
B=	-20765
C=	0
D=	0
T(K)=	1873.15

log P = -4.42E+00

P= 3.81E-05 atm

Nickel Emission Estimates

Nickel Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=	lb-mole Ni	
P=	3.81E-05	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	1.60E-08	lb-mole Ni
	58.71	lb Ni/lb-mole Ni
	9.42E-07	lb Ni
Or mass concentration =	9.07E-07	lb Ni/ft^3

Uncontrolled Nickel Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Ni during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Ni concentration within glove box prior to exhaust

	9.07E-07	lb Ni/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	9.07E-06	lb Ni/hr	

Controlled Nickel Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	4.54E-09	lb Ni/hr

Notes

[1] From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

[2] Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Copper Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Copper Melting Point[(1)]	1084.62	C
	1357.77	K

Copper Vapor Pressure at 1600 C

Assume: Cu solid/liquid and vapor is at equilibrium in furnace

[(2)] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	5.849
B=	-16415
C=	0
D=	0
T(K)=	1873.15

log P = -2.91E+00

P= 1.22E-03 atm

Copper Emission Estimates

Copper Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=	lb-mole Cu	
P=	1.22E-03	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	5.14E-07	lb-mole Cu
	63.54	lb Cu/lb-mole Cu
	3.26E-05	lb Cu
Or mass concentration =	3.14E-05	lb Cu/ft^3

Uncontrolled Copper Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Cu during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Cu concentration within glove box prior to exhaust

	3.14E-05	lb Cu/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	3.14E-04	lb Cu/hr	

Controlled Copper Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	1.57E-07	lb Cu/hr

Notes

[1] From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

[2] Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Iron Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Iron Melting Point(1)	1538	C
	1811.15	K
Stainless Steel Melting Point(1)	1425	C

Iron Vapor Pressure at 1600 C

Assume: Fe solid/liquid and vapor is at equilibrium in furnace

(2) $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	6.347
B=	-19574
C=	0
D=	0
T(K)=	1873.15

log P = -4.10E+00

P= 7.89E-05 atm

Iron Emission Estimates

Iron Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole Fe
P=	7.89E-05	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	3.33E-08	lb-mole Fe
	55.85	lb Fe/lb-mole Fe
	1.86E-06	lb Fe
Or mass concentration =	1.79E-06	lb Fe/ft^3

Uncontrolled Iron Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Fe during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Fe concentration within glove box prior to exhaust

	1.79E-06	lb Fe/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	1.79E-05	lb Fe/hr	

Controlled Iron Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	8.95E-09	lb Fe/hr

Notes

(1) From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2) Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Chromium Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Chromium Melting Point[1]	1907	C
	2180.15	K
Stainless Steel Melting Point[1]	1425	C

Chromium Vapor Pressure at 1600 C

Assume: Cr solid/liquid and vapor is at equilibrium in furnace

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	6.8
B=	-20733
C=	0.4391
D=	-0.4094
T(K)=	1873.15

log P = -2.83E+00

P= 1.47E-03 atm

Chromium Emission Estimates

Chromium Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=	lb-mole Cr	
P=	1.47E-03	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	6.21E-07	lb-mole Cr
	52.00	lb Cr/lb-mole
	3.23E-05	lb Cr
Or mass concentration =	3.11E-05	lb Cr/ft^3

Uncontrolled Chromium Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Cr during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Cr concentration within glove box prior to exhaust

	3.11E-05	lb Cr/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	3.11E-04	lb Cr/hr	

Controlled Chromium Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	1.56E-07	lb Cr/hr

Notes

[1] From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

[2] Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Molybdenum Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Molybdenum Melting Point[1]	2622	C
	2895.15	K
Stainless Steel Melting Point[1]	1425	C

Molybdenum Vapor Pressure at 1600 C

Assume: Mo solid/liquid and vapor is at equilibrium in furnace

[2] $\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	11.529
B=	-34626
C=	-1.1331
D=	0
T(K)=	1873.15

log P = -1.07E+01

P= 2.16E-11 atm

Molybdenum Emission Estimates

Molybdenum Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=	lb-mole Mo	
P=	2.16E-11	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	9.13E-15	lb-mole Mo
	95.94	lb Mo/lb-mole Mo
	8.76E-13	lb Mo
Or mass concentration =	8.44E-13	lb Mo/ft^3

Uncontrolled Molybdenum Particulate Mass Emission Rate

Conservative assumptions:

- Continuous melt of Mo during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Mo concentration within glove box prior to exhaust

	8.44E-13	lb Mo/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	8.44E-12	lb Mo/hr	

Controlled Molybdenum Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	4.22E-15	lb Mo/hr

Notes

(1) From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2) Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Manganese Emission Estimates

Operational Data

Furnace Chamber Volume	12	in length
	11.5	in height
	13	in width
Volume	1794.00	in^3
	1.04	ft^3
Maximum Operating Temperature	1600	C
	3371.67	R
	1873.15	K
Maximum Glove Box Flowrate	10	ft^3/hr
Manganese Melting Point[(1)]	1246	C
	1519.15	K
Stainless Steel Melting Point[(1)]	1425	C

Manganese Vapor Pressure at 1600 C

Assume: Mn solid/liquid and vapor is at equilibrium in furnace

[2]$\log P = A + BT^{-1} + C(\log T) + DT^{-3}$ where:

P is pressure in atm

A=	12.805
B=	-15097
C=	-1.7896
D=	0
T(K)=	1873.15

log P = -1.11E+00

P= 7.74E-02 atm

Manganese Emission Estimates

Manganese Vapor Mass in Furnace

Using Ideal Gas Law n = PV/RT where:

n=		lb-mole Mn
P=	7.74E-02	atm
V =	1.04E+00	ft^3
R=	0.7302	
T=	3371.67	R
n=	3.26E-05	lb-mole Mn
	54.94	lb Mn/lb-mole Mn
	1.79E-03	lb Mn
Or mass concentration =	1.73E-03	lb Mn/ft^3

Uncontrolled Manganese Particulate Mass Emission Rate

Conservative assumptions:
- Continuous melt of Mn during full hour time period
- Continuous flow from furnace to glove box
- No dilution of Mn concentration within glove box prior to exhaust

	1.73E-03	lb Mn/ft^3	Mass concentration from furnace
	10	ft^3/hr	Maximum glove box flowrate
Emission rate =	1.73E-02	lb Mn/hr	

Controlled Manganese Particulate Mass Emission Rate

Conservative assumption:	99.95	% installed removal efficiency - credit for (1) of (4) HEPA filtration stages
Emission rate =	8.64E-06	lb Mn/hr

Notes

(1) From CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

(2) Equation and constants from CRC Handbook of Chemistry and Physics, 85th Edition on-line, Section 4

Attachment D

Emissions Information

VAPOR PRESSURE OF THE METALLIC ELEMENTS

C. B. Alcock

This table gives coefficients in an equation for the vapor pressure of 65 metallic elements in both the solid and liquid state. Vapor pressures in the range 10^{-10} to 10^{2} Pa (10^{-15} to 10^{-3} atm) are covered. The equation is:

for p in pascals: $\log (p/\mathrm{Pa}) = 5.006 + A + BT^{-1} + C\log T + DT^{-3}$

for p in atmospheres: $\log(p/\mathrm{atm}) = A + BT^{-1} + C\log T + DT^{-3}$, where T is the temperature in K

This equation reproduces the observed vapor pressures to an accuracy of ±5% or better. Reprinted with permission of the publisher, Pergamon Press.

REFERENCE

Alcock, C. B., Itkin, V. P., and Horrigan, M. K., *Canadian Metallurgical Quarterly*, 23, 309, 1984.

Element, state	*A*	*B*	*C*	*D*	Temperature range
Li sol	5.667	-8310			298-m.p.
Li liq	5.055	-8023			m.p.-1000
Na sol	5.298	-5603			298-m.p.
Na liq	4.704	-5377			m.p.-700
K sol	4.961	-4646			298-m.p.
K liq	4.402	-4453			m.p.-600
Rb sol	4.857	-4215			298-m.p.
Rb liq	4.312	-4040			m.p.-550
Cs sol	4.711	-3999			298-m.p.
Cs liq	4.165	-3830			m.p.-550
Be sol	8.042	-17020	-0.4440		298-m.p.
Be liq	5.786	-15731			m.p.-1800
Mg sol	8.489	-7813	-0.8253		298-m.p.
Ca sol	10.127	-9517	-1.4030		298-m.p.
Sr sol	9.226	-8572	-1.1926		298-m.p.
Ba sol	12.405	-9690	-2.2890		298-m.p.
Ba liq	4.007	-8163			m.p.-1200
Al sol	9.459	-17342	-0.7927		298-m.p.
Al liq	5.911	-16211			m.p.-1800
Ga sol	6.657	-14208			298-m.p.
Ga liq	6.754	-13984	-0.3413		m.p.-1600
In sol	5.991	-12548			298-m.p.
In liq	5.374	-12276			m.p.-1500
Tl sol	5.971	-9447			298-m.p.
Tl liq	5.259	-9037			m.p.-1100
Sn sol	6.036	-15710			298-m.p.
Sn liq	5.262	-15332			m.p.-1850
Pb sol	5.643	-10143			298-m.p.
Pb liq	4.911	-9701			m.p.-1200
Sc sol	6.650	-19721	0.2885	-0.3663	298-m.p.
Sc liq	5.795	-17681			m.p.-2000
Y sol	9.735	-22306	-0.8705		298-m.p.
Y liq	5.795	-20341			m.p.-2300
La sol	7.463	-22551	-0.3142		298-m.p.
La liq	5.911	-21855			m.p.-2450
Ti sol	11.925	-24991	-1.3376		298-m.p.
Ti liq	6.358	-22747			m.p.-2400
Zr sol	10.008	-31512	-0.7890		298-m.p
Zr liq	6.806	-30295			m.p.-2500
Hf sol	9.445	-32482	-0.6735		298-m.p.
V sol	9.744	-27132	-0.5501		298-m.p.

VAPOR PRESSURE OF THE METALLIC ELEMENTS (continued)

Element, state	*A*	*B*	*C*	*D*	Temperature range
V liq	6.929	-25011			m.p.-2500
Nb sol	8.822	-37818	-0.2575		298-2500
Ta sol	16.807	-41346	-3.2152	0.7437	248-2500
Cr sol	6.800	-20733	0.4391	-0.4094	298-2000
Mo sol	11.529	-34626	-1.1331		298-2500
W sol	2.945	-44094	1.3677		298-2350
W sol	-54.527	-57687	-12.2231		2200-2500
Mn sol	12.805	-15097	-1.7896		298-m.p.
Re sol	11.543	-40726	-1.1629		298-2500
Fe sol	7.100	-21723	0.4536	-0.5846	298-m.p.
Fe liq	6.347	-19574			m.p.-2100
Ru sol	9.755	-34154	-0.4723		298-m.p.
Os sol	9.419	-41198	-0.3896		298-2500
Co sol	10.976	-22576	-1.0280		298-m.p.
Co liq	6.488	-20578			m.p.-2150
Rh sol	10.168	-29010	-0.7068		298-m.p.
Rh liq	6.802	-26792			m.p.-2500
Ir sol	10.506	-35099	-0.7500		298-2500
Ni sol	10.557	-22606	-0.8717		298-m.p.
Ni liq	6.666	-20765			m.p.-2150
Pd sol	9.502	-19813	-0.9258		298-m.p.
Pd liq	5.426	-17899			m.p.-2100
Pt sol	4.882	-29387	1.1039	-0.4527	298-m.p.
Pt liq	6.386	-26856			m.p.-2500
Cu sol	9.123	-17748	-0.7317		298-m.p.
Cu liq	5.849	-16415			m.p.-1850
Ag sol	9.127	-14999	-0.7845		298-m.p.
Ag liq	5.752	-13827			m.p.-1600
Au sol	9.152	-19343	-0.7479		298-m.p.
Au liq	5.832	-18024			m.p.-2050
Zn sol	6.102	-6776			298-m.p.
Zn liq	5.378	-6286			m.p.-750
Cd sol	5.939	-5799			298-m.p.
Cd liq	5.242	-5392			m.p.-650
Hg liq	5.116	-3190			298-400
Ce sol	6.139	-21752			298-m.p.
Ce liq	5.611	-21200			m.p.-2450
Pr sol	8.859	-18720	-0.9512		298-m.p.
Pr liq	4.772	-17315			m.p.-2200
Nd sol	8.996	-17264	-0.9519		298-m.p.
Nd liq	4.912	-15824			m.p.-2000
Sm sol	9.988	-11034	-1.3287		298-m.p.
Eu sol	9.240	-9459	-1.1661		298-m.p.
Gd sol	8.344	-20861	-0.5775		298-m.p.
Gd liq	5.557	-19389			m.p.-2250
Tb sol	9.510	-20457	-0.9247		298-m.p.
Tb liq	5.411	-18639			m.p.-2200
Dy sol	9.579	-15336	-1.1114		298-m.p.
Ho sol	9.785	-15899	-1.1753		298-m.p.
Er sol	9.916	-16642	-1.2154		298-m.p.
Er liq	4.668	-14380			m.p.-1900
Tm sol	8.882	-12270	-0.9564		298-1400
Yb sol	9.111	-8111	-1.0849		298-900
Lu sol	8.793	-22423	-0.6200		298-m.p.
Lu liq	5.648	-20302			m.p.-2350
Th sol	8.668	-31483	-0.5288		298-m.p.
Th liq	-18.453	-24569	6.6473		m.p.-2500
Pa sol	10.552	-34869	-1.0075		298-m.p.

VAPOR PRESSURE OF THE METALLIC ELEMENTS (continued)

Element, state	***A***	***B***	***C***	***D***	**Temperature range**
Pa liq	6.177	-32874			m.p.-2500
U sol	0.770	-27729	2.6982	-1.5471	298-m.p.
U liq	20.735	-28776	-4.0962		m.p.-2500
Np sol	19.643	-24886	-3.9991		298-m.p.
Np liq	10.076	-23378	-1.3250		m.p.-2500
Pu sol	26.160	-19162	-6.6675		298-600
Pu sol	18.858	-18460	-4.4720		500-m.p.
Pu liq	3.666	-16658			m.p.-2450
Am sol	11.311	-15059	-1.3449		298-m.p.
Cm sol	8.369	-20364	-0.5770		298-m.p.
Cm liq	5.223	-18292			m.p.-2200

MELTING, BOILING, TRIPLE, AND CRITICAL POINT TEMPERATURES OF THE ELEMENTS

This table summarizes the significant points on the phase diagrams for the elements for which data are available. Values are given for the solid-liquid-gas triple point t_{tp}, normal melting point t_m, normal boiling point t_b, and critical temperature t_c; all are on the ITS-90 scale. An "sp" notation indicates a sublimation point, where the vapor pressure of the solid phase reaches 101.325 kPa (1 atm). Transition temperatures between allotropic forms are included for several elements. The major data sources are listed below; values from Reference 1, which deals with reference points on the ITS-90 scale, were adopted when applicable.

REFERENCES

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4. Gurvich, L.V., Veyts, I.V., and Alcock, C.B., *Thermodynamic Properties of Individual Substances, Fourth Edition,* Hemisphere Publishing Corp., New York, 1989.
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Element	t_{tp}/°C	t_m/°C	t_b/°C	t_c/°C
Actinium		1051	3198	
Aluminum		660.32	2519	
Americium		1176	2011	
Antimony		630.628	1587	
Argon	-189.36 (69 kPa)		-185.847	-122.28
Arsenic (gray)	817 (3.70 MPa)		603 sp	1400
Astatine		302		
Barium		727	1897	
Berkelium (α form)		1050		
Berkelium (β form)		986		
Beryllium		1287	2471	
Bismuth		271.402	1564	
Boron		2075	4000	
Bromine		-7.2	58.8	315
Cadmium		321.069	767	
Calcium		842	1484	
Californium		900		
Carbon (graphite)	4489 (10.3 MPa)		3825 sp	
Carbon (diamond)		4440 (12.4 GPa)		
Cerium		798	3443	
Cesium		28.5	671	1665
Chlorine		-101.5	-34.04	143.8
Chromium		1907	2671	
Cobalt		1495	2927	
Copper		1084.62	2562	
Curium		1345	~3100	
Dysprosium		1412	2567	
Einsteinium		860		
Erbium		1529	2868	
Europium		822	1529	
Fermium		1527		
Fluorine	-219.67		-188.12	-129.02
Francium		27		
Gadolinium		1313	3273	
Gallium	29.7666		2204	
Germanium		938.25	2833	
Gold		1064.18	2856	
Hafnium		2233	4603	
Helium			-268.93	-267.96
Holmium		1474	2700	

MELTING, BOILING, TRIPLE, AND CRITICAL POINT TEMPERATURES OF THE ELEMENTS (continued)

Element	t_{tp}/°C	t_m/°C	t_b/°C	t_c/°C
Hydrogen	-259.198 (7.2 kPa)	-259.1	-252.762	-240.18
Indium	156.5936	156.60	2072	
Iodine		113.7	184.4	546
Iridium		2446	4428	
Iron		1538	2861	
Krypton	-157.375 (73.2 kPa)		-153.34	-63.74
Lanthanum		918	3464	
Lawrencium		1627		
Lead		327.462	1749	
Lithium		180.50	1342	2950
Lutetium		1663	3402	
Magnesium		650	1090	
Manganese		1246	2061	
Mendelevium		827		
Mercury	-38.837	-38.8290	356.62	1477
Molybdenum		2622	4639	
Neodymium		1021	3074	
Neon	-248.609 (43 kPa)		-246.053	-228.7
Neptunium		644		
Nickel		1455	2913	
Niobium		2477	4744	
Nitrogen	-209.999	-210.0	-195.798	-146.94
Nobelium		827		
Osmium		3033	5012	
Oxygen		-218.79	-182.953	-118.56
Palladium		1554.8	2963	
Phosphorus (white)		44.15	280.5	721
Phosphorus (red)	590		431 sp	721
Phosphorus (black)		610		
Platinum		1768.2	3825	
Plutonium		640	3228	
Polonium		254	962	
Potassium		63.5	759	1950
Praseodymium		931	3520	
Promethium		1042	3000	
Protactinium		1572		
Radium		700		
Radon		-71	-61.7	104
Rhenium		3186	5596	
Rhodium		1963	3695	
Rubidium	39.26	39.30	688	1820
Ruthenium		2333	4150	
Samarium		1074	1794	
Scandium		1541	2836	
Selenium (vitreous)		180 (trans to gray)	685	1493
Selenium (gray)		220.5	685	1493
Silicon		1414	3265	
Silver		961.78	2162	
Sodium		97.794	882.940	2300
Strontium		777	1382	
Sulfur (rhombic)		95.3 (trans to monocl)	444.61	1041
Sulfur (monoclinic)		115.21	444.61	1041
Tantalum		3007	5458	
Technetium		2157	4265	

MELTING, BOILING, TRIPLE, AND CRITICAL POINT TEMPERATURES OF THE ELEMENTS (continued)

Element	t_{tp}/°C	t_m/°C	t_b/°C	t_c/°C
Tellurium		449.51	988	
Terbium		1356	3230	
Thallium		304	1473	
Thorium		1750	4788	
Thulium		1545	1950	
Tin (gray)		13.2 (trans to white)	2602	
Tin (white)		231.93	2602	
Titanium		1670	3287	
Tungsten		3414	5555	
Uranium		1135	4131	
Vanadium		1910	3407	
Xenon	-111.745 (81.6 kPa)		-108.09	16.62
Ytterbium		819	1196	
Yttrium		1522	3345	
Zinc		419.53	907	
Zirconium		1854	4409	

COMMERCIAL METALS AND ALLOYS

This table gives typical values of mechanical, thermal, and electrical properties of several common commercial metals and alloys. Values refer to ambient temperature (0 to 25°C). All values should be regarded as typical, since these properties are dependent on the particular type of alloy, heat treatment, and other factors. Values for individual specimens can vary widely.

REFERENCES

1. *ASM Metals Reference Book, Second Edition*, American Society for Metals, Metals Park, OH, 1983.
2. Lynch, C. T., *CRC Practical Handbook of Materials Science*, CRC Press, Boca Raton, FL, 1989.
3. Shackelford, J. F., and Alexander, W., *CRC Materials Science and Engineering Handbook*, CRC Press, Boca Raton, FL, 1991.

Common name	**Thermal conductivity W/cm K**	**Density g/cm³**	**Coeff. of linear expansion 10^{-6}/°C**	**Electrical resistivity μΩ cm**	**Modulus of elasticity GPa**	**Tensile strength MPa**	**Approx. melting point °C**
Ingot iron	0.7	7.86	11.7	9.7	205	-	1540
Plain carbon steel AISI-SAE 1020	0.52	7.86	11.7	18	205	450	1515
Stainless steel type 304	0.15	7.9	17.3	72	195	550	1425
Cast gray iron	0.47	7.2	10.5	67	90	180	1175
Malleable iron		7.3	12	30	170	345	1230
Hastelloy C	0.12	8.94	11.3	125	200	780	1350
Inconel	0.15	8.25	11.5	103	200	800	1370
Aluminum alloy 3003, rolled	1.9	2.73	23.2	3.7	70	110	650
Aluminum alloy 2014, annealed	1.9	2.8	23.0	3.4	70	185	650
Aluminum alloy 360	1.5	2.64	21.0	7.5	70	325	565
Copper, electrolytic (ETP)	3.9	8.94	16.5	1.7	120	300	1080
Yellow brass (high brass)	1.2	8.47	20.3	6.4	100	300-800	930
Aluminum bronze	0.7	7.8	16.4	12	120	400-600	1050
Beryllium copper 25	0.8	8.23	17.8	7	130	500-1400	925
Cupronickel 30%	0.3	8.94	16.2		150	400-600	1200
Red brass, 85%	1.6	8.75	18.7	11	90	300-700	1000
Chemical lead	0.35	11.34	29.3	21	13	17	327
Antimonial lead (hard lead)	0.3	10.9	26.5	23	20	47	290
Solder 50-50	0.5	8.89	23.4	15	-	42	215
Magnesium alloy AZ31B	1.0	1.77	26	9	45	260	620
Monel	0.3	8.84	14.0	58	180	545	1330
Nickel (commercial)	0.9	8.89	13.3	10	200	460	1440
Cupronickel 55-45 (constantan)	0.2	8.9	18.8	49	160	-	1260
Titanium (commercial)	1.8	4.5	8.5	43	110	330-500	1670
Zinc (commercial)	1.1	7.14	32.5	6	-	130	419
Zirconium (commercial)	0.2	6.5	5.85	41	95	450	1855

Attachment E

Proof of Public Notice

NOTICE OF AIR QUALITY PERMIT APPLICATION

Pursuant to the requirements of Title 20 of the New Mexico Administrative Code, Chapter 2, Part 72 (20.2.72 NMAC – CONSTRUCTION PERMITS, Section 203.B, the University of California, operator of Los Alamos National Laboratory for the U.S. Department of Energy at P.O. Box 1663, MS J978, Los Alamos, New Mexico 87545 hereby announces the intent to apply to the New Mexico Environment Department, Air Quality Bureau, for a revision to air quality New Source Review (NSR) Permit 1081 for the Nuclear Materials Technology (NMT) Division's beryllium machining and melting operations. An air quality permit revision is sought to replace an existing laboratory scale beryllium melt furnace with a different model furnace. The expected date of application submittal to the NMED is April 2006.

The NMT Division's beryllium operations in Permit 1081 are located within Technical Area (TA)-55 in Township 19 North, Range 6 East, Section 21, approximately 1 mile south of Los Alamos in Los Alamos County.

The estimated plant-wide, maximum air emissions and air pollutants, from the new beryllium melt furnace will be equivalent to the existing emission limits in Permit 1081 of 3.49×10^{-5} grams beryllium per 24 hours and 8.73×10^{-4} grams beryllium per year. This application requests no change to beryllium machining operations, and maximum air emissions will remain equivalent to the existing emission limits in Permit 1081 of 0.12 grams beryllium per 24 hours and 2.99 grams beryllium per year. The standard operating schedule for the facility is 8 hours per day, 5 days per week, and 51 weeks per year. The maximum operating schedule for the facility is 24 hours per day, 7 days per week, and 52 weeks per year. The permit applicant and operator is the University of California at P.O. Box 1663, MS J978, Los Alamos, New Mexico 87545. The owner of the facility is the U.S. Department of Energy, Office of Los Alamos Site Operations, 528 35th Street, Los Alamos, NM 87544. Inquiries about the permitting process or relevant comments or questions regarding this permit application may be directed to:

> Program Manager, New Source Review
> New Mexico Environment Department
> Air Quality Bureau
> 2048 Galisteo
> Santa Fe, New Mexico 87505
> (505) 827-1494

Please refer to the company name and site name, as used in this notice or send a copy of this notice when making inquiries since the Department might not have received the permit application at the time of this notice. A copy of the application may be obtained at: http://www.airquality.lanl.gov/ConstrPermit.htm.

NOTICIA DE SOLICITUD PARA UN PERMISO DE CALIDAD DEL AIRE

En cuanto a los requisitos del Título 20 del Código Administrativo de Nuevo México, Capítulo 2, Sección 72 (20.2.72 NMAC—PERMISOS DE CONSTRUCCION, Sección 203.B, la Universidad de California (University of California), operador del Laboratorio de Los Alamos (Los Alamos National Laboratory) para el Departamento de Energía de los Estados Unidos (U.S. Department of Energy) en la dirección de correo, P.O. Box 1663, MS J978, Los Alamos, New Mexico 87545, en este documento se anuncia el intento de someter un pedido al Departamento del Ambiente de Nuevo México, la Agencia de Calidad del Aire, para una revisión del Permiso 1081, Revisión de Nueva Fuente (NSR) en cuanto a la calidad del aire cuando están labrando y derritiendo berilio para la División de Tecnología de Materiales Nucleares (NMT). Se pide una revisión del permiso de calidad del aire para reponer la escala existente del laboratorio para el horno de derritir berilio con un modelo diferente de horno. La fecha esperada de someter la aplicación a NMED es en Abril de 2006.

Las operaciones con berilio de La División NMT en el Permiso 1081 están localizadas dentro del Area Técnico (TA) 55 en el área del Municipio 19 Norte, Campo de Tiro 6 Este, Sección 21, localizado aproximadamente una milla al sur del pueblo de Los Alamos en el Condado de Los Alamos.

La estimada contaminación (emisiones máximas al aire y contaminantes del aire) del horno nuevo de derritir berilio será el equivalente a los límites existentes en el Permiso 1081 de $3{,}49 \times 10^{-5}$ gramos por 24 horas y $8{,}73 \times 10^{-4}$ gramos de berilio por año. Esta aplicación pide que no hayan ningunos cambios a las operaciones de labrar el berilio, y las emisiones máximas al aire se quedarán iguales a los límites existentes de emisión descritos en el Permiso 1081 de 0,12 gramos de berilio en 24 horas y 2,99 gramos de berilio al año. El horario normal de la facilidad es 8 horas al día, 5 días por semana y 51 semanas al año. El horario máximo de la facilidad es 24 horas al día, 7 días por semana y 52 semanas por año. El solicitante del permiso y operador es la University of California, P.O. Box 1663, MS J978, Los Alamos, New Mexico 87545. El dueño de la facilidad es el U.S. Department of Energy, Office of Los Alamos Site Operations, 528 35th Street, Los Alamos, New Mexico 87544. Preguntas sobre el proceso del permiso o observaciones en cuanto a esta aplicación para permiso se pueden dirigir a

Program Manager, New Source Review
New Mexico Environment Department
Air Quality Bureau
2048 Galisteo
Santa Fe, New Mexico 87505
(505) 827-1494

Favor de indicar el nombre de la compañía y su sitio, como se usa en esta noticia, o favor de mandar una copia de esta noticia cuando comunica sus preguntas porque el Departamento tal vez no haya recibido la aplicación de permiso en el momento de esta noticia. Se puede obtener una copia de la solicitud de permiso en la siguiente dirección: http://www.airquality.lanl.gov/ConstrPermit.htm.

CERTIFIED MAIL **XXXX XXXX XXXX XXXX**
RETURN RECEIPT REQUESTED

Dear **[Municipal, County, or Tribal Official]**

This letter is to notify you that the University of California, operator of Los Alamos National Laboratory for the U.S. Department of Energy is preparing to apply to the New Mexico Environment Department, Air Quality Bureau for a revision to air quality New Source Review (NSR) Permit 1081 for the Nuclear Materials Technology (NMT) Division's beryllium machining and melting operations. This notice is a requirement of 20.2.72 NMAC – CONSTRUCTION PERMITS.

We expect to submit the permit application to the New Mexico Environment Department, Air Quality Bureau in April 2006. The NMT Division's beryllium operations in Permit 1081 are located within Technical Area (TA)-55 in Township 19 North, Range 6 East, Section 21, approximately 1 mile south of Los Alamos in Los Alamos County.

An air quality permit revision is sought to replace an existing laboratory scale beryllium melt furnace with a different model furnace.

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Inquiries about the permitting process or relevant comments or questions regarding this permit application may be directed to:

> Program Manager, New Source Review
> New Mexico Environment Department
> Air Quality Bureau
> 2048 Galisteo
> Santa Fe, New Mexico 87505
> (505) 827-1494

If you send written comments to the Department, please be sure to note the name of the company and the name of the site or include a copy of this letter along with your comments so that the Department can determine the permit application to which your comments refer. Also include your mailing address in your response. A copy of the application may be obtained at: http://www.airquality.lanl.gov/ConstrPermit.htm.

Sincerely,

Dianne Wilburn
Acting Group Leader
Meteorology and Air Quality Group
Los Alamos National Laboratory
P.O. Box 1663, MS J978
Los Alamos New Mexico, 87545

Cy:
R. Chavarria, NMT-15
H. Decker, NMT-7
J. Hurtle, ENV-MAQ
B. Blankenship, ENV-MAQ
P. Wardwell, LC
ENV-MAQ File
ENV-MAQ Permit 1081 File

List of Municipalities and Counties Requiring Certified Notification

Los Alamos County Clerk
P.O. Box 30
Los Alamos, New Mexico 87544

Governor, Cochiti Pueblo
P.O. Box 70
Cochiti Pueblo, New Mexico 87072

Sandoval County Clerk
P.O. Box 40
Bernalillo, New Mexico 87004

Santa Fe County Clerk
P.O. Box 1985
Santa Fe, New Mexico 87501

Governor, San Ildefonso Pueblo
Route 5, Box 315A
Santa Fe, New Mexico 87506

Governor, Santa Clara Pueblo
P.O. Box 580
Espanola, New Mexico 87532

Espanola City Manager
P.O. Drawer 37
Espanola, New Mexico 87532

Governor, Jemez Pueblo
P.O. Box 100
Jemez Pueblo, New Mexico 87024

Governor, Pojoaque Pueblo
Route 11, Box 71
Santa Fe, New Mexico 87501

Rio Arriba County Clerk
P.O. Box 158
Tierra Amarilla, New Mexico 87575
Or
P.O. Box 1256
Espanola, New Mexico 87532